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APPRAISAL OF EXISTING POWER RESOURCES AND FORESEEABLE REQUIREMENTS

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1. Appraisal of the sources of fuel and power

(a) An essential condition for the development of the power production of a country is a good knowledge of its energy resources. After World War II in Yugoslavia there was no index to the actual balance of reserves of the sources of fuel and power, but it was estimated that the potential of the deposits of low calor coal and water power was high, while the known deposits of petroleum and natural gas were quite insignificant.

As the reserves of energy had been only poorly investigated, in order to produce the conditions for the industrialization of the country large scale prospecting had to be undertaken which gave important results but which required the expenditure of considerable resources and time.

It has been shown that the water power potential, estimated before the war at 24 billion kWh and 5,000 MW, amounts today to 66.5 billion kWh and 16,500 MW. The coal reserves, previously estimated at 4.8 billions of tons, have risen to approximately 21 billion tons. Previously there were no known commercially useful petroleum reserves, while now they amount to more than 30 million tons of petroleum and over 13 billions standard cubic metres of natural gas.

(b) As far as water power and coal are concerned, no increase of reserves is foreseen. In the case of water power, the investigations are directed towards integrated solutions for individual river basins, in order to obtain a more complete insight into the economic classification of water power capacities. Prospecting for coal tends to increase the commercially useful reserves. In the case of petroleum,an increase of the reserves is already expected on the strenght of the drilling undertaken so far. The increase of natural gas which this will involve should be especially notable.

(c) The great increase of the reserves of the main sources of fuel and power has had a considerable influence on the development of the power industry of the country which shows in the fact that 92 percent of the total domestic fuel and power requirements are covered by home production and only 8 percent by imports,

2. The role of the power industry in the planning of economic development

(a) The experience acquired in Yugoslavia so far has shown that the development of the power industry has been coupled very closely with the development of the economy as a whole and consequently the fact could not be overlooked that the fuel and power supply had to be assured on the scale imposed by the economic development of the country. In the past period from 1951 to 1961, this dependence showed itself in the fact,that at the same time as a 6.8 percent increase of the Gross National Product was attained, the fuel and power consumption rose by 8. percent, not including fire wood consumption. Hydroelectric power was taken as equivalent to the heat consumption for the generation of thermoelectric power and the various kinds of solid, liquid and gaseous fuels at their factual calorific equivalents.

(b) The interdependence between the development of the power industry and of the economy as a whole manifested itself not only in the statistical proportions shown by this relationship, but also in the fact that the economic and technological features of energy resources and the choice of the most economic form of energy, with the interchangeability of the various kinds of energy in view, had to be taken into consideration too.

In spite of the well-known fact that Yugoslavia possesses considerable sources of hydroelectric power and coal, it was out of the question during the first period to build mainly big, truly economic hydroelectrical plants or to open only large coal mines with massive outputs. This was partly on account of insufficient surveys and lack of planning and partly because the considerable funds necessary were not available. The interchangeability of the various forms

of energy manifested itself chiefly through a decline in the use of coal in favour of other kinds of fuel, expecially petroleum and natural gas, the output of which is steadily rising.

In 1951 the part played by coal in the total energy consumption amounted to 75.8 percent and in 1961 to only 68.9 percent with a tendency to further decline, the main reason for this being that several big coal consumers (railways, sea and river shipping) gradually switched over to liquid fuel.

(c) With the establishment of the development trends of Yugoslav power economy, the technological factors asserted themselves to a greater extent than expected. This was because of the great changes which have occured, especially recently, in the technology of energy production and consumption. The specific heat consumption in the thermoelectric power plants, for example, amounted in 1951 to 6,960 kcal/kWh and in 1961 to 4,100 kcal/kWh. In the transformation of primary energy into the main forms of secondary energy not only was the output obtained approximately 3.2 times greater, which created a considerable increase in the total volume, but also a perceptible improvement of the average efficiency of utilization was shown in its rise from 48 percent in 1951 to 66.3 percent in 1961. Since far-reaching and complex consequences may arise from such changes it is of the utmost importance to assess the advantage offered by these circumstances properly and to utilize them to the maximum. This entails the necessity of defining a uniform conception of the development of power economy which should include the orientation of both energy production and consumption, and ensure the most favourable production structure through the application of up-to-date technological achievements, an increase in the efficiency of utilization and the tendency towards a continuous reduction of specific energy consumption.

(d) An important factor in the development of power economy, especially in underdeveloped countries, is the balance of payments which can largely dictate the degree of utilization of domestic sources of fuel and power. The Yugoslav balance of payments dictated the maximum utilization of domestic sources of fuel and power, but the shortage of coking coal and petroleum had to be covered by imports. Great efforts were made to reduce the imports of fuel and power by intensive prospecting for petroleum with the result that the share of fuel and power in the foreign exchange balance of industry sank from 16 percent in 1951 to 9 percent in 1961. In countries with a debit foreign exchange balance the utilization of domestic sources of energy is economically justified even if they cost more than imported sources of fuel and power.

(e) The postwar development of Yugoslavia's economy was conditioned by the speeded-up development of industry. This industrial development required adequate investments in the power industry. The building up of the fuel and power industries demands great capital investment, their starting period and amortization are long, and since the fact that they are basic industries has to be taken into consideration, all this necessitated finding the most economic solutions.

The investments in the fuel and power industry account for a high proportion of the total investments in the economy. The sums invested in the Yugoslav power economy during the last ten years have amounted to an average of 18 percent of the total investments in the economy and to 33 percent of the total of industrial investments. The ratio of the investments in the power economy to the investments in the economy as a whole is continually rising. It amounted to 28.3 percent during the period 1947-1949, to 30.3 percent during the period 1950-1952, rose to 34 percent in the period 1953-1956, and to 35,6 percent during 1957-1960. On the other hand, the share of the fuel and power industries in the Gross National Product of the economy as a whole has amounted to an average of 5.5 percent and its share in the Gross National Product of industry to 13 percent showing that the investments in the power industry are very intensive, but poorly accumulating. This has necessitated an exceedingly careful choice of investment projects from the point of view of their productiveness.

3. The interdependence of long-term energy consumption forecasts and important economic values

(a) A quantitative global survey of the long-term development of the consumption of energy and the corresponding energy producing potential requires an analysis of the longest possible foregoing period from all points of view and the adoption of certain assumptions relating to the development of the basic macroeconomic values, made in the light of the rate of growth and structural re-

lations. This refers in the first place to the development of the Gross National Product of the whole economy and of certain of its branches, to the rate of capital accumulation and to the rise in the standard of living.

The adopted basic macroeconomic variables should make it possible to fix the probable figures for the future consumption of energy through more or less firm, probable and functional correlations resulting from the past development and a similar interdependence in other countries.

It is obvious, that in order to obtain a more realistic view it has been necessary to determine in addition to the basic postulates also other more detailed data relevant to the estimation of energy consumption, as for example the development of individual large consumers of energy, the development of the motorization and electrification of transport etc.

(b) In order to establish the correlation between the movement of the relevant economic values and the consumption of energy, as well as to form a picture of the manner in which to ensure this supply, it has been found indispensable to draw up an integrated and comprehensive balance of energy. As the fact had to be taken into consideration that energy is used partly directly as primary energy and partly after undergoing multiple processing phases transformed into secondary energy, the main sectors of the domain of the fuel and power economy, from production, imports, exports, transformation, and stocks to consumption of energy ranged according to the main fields of consumption i.e. industry, transport, agriculture, mass consumption and others, were taken into account in the drawing up to the balance.

4. Comparison of the various methods of appraising fuel and power requirements

(a) The method of estimating future requirements of fuel and power does not differ substantially from the methods employed in forecasting in various branches of economy /development of individual fields of economy, the supply of important commodities: steel, cement etc./. It must be pointed out, however, that the methodology of estimating in the power economy is far more intricate for the reason that the interdependence between the individual basic values is subject to considerable fluctuations owing to very many factors (the interchange of the various forms of energy, the structure and characteristics of the sources of fuel and power, technological advances in the generation and utilization of power, current rate policy, the balance of payments, conveyance, etc.). Power economy forecasting is faced with these difficulties, which lead to greater or lesser departures from the results obtained, but establishes nevertheless a certain framework inside of which realistic estimations may vary.

Yugoslav experience shows that the results obtained by estimating the overall needs provide data which are not sufficiently reliable, so that it is much more realistic to make a survey and analysis of each sector of consumption separately taking into account the modifications to be expected.

(b) The main methods which were applied when estimating the development of the fuel and power industry in Yugoslavia were limited chiefly to five groups:

(i) linear extrapolation on the basis of the trends and movements which manifested themselves during the foregoing period;

(ii) extrapolation of the independent time trend of the consumption of energy by taking the exponential trend ensuring the constant rate of growth attained in the foregoing period;

(iii) extrapolation of certain interdependences, based on some functional probable correlation between two or more variables (the extrapolation was subordinated to the movements of the National Product and the volume of industrial production;

(iiii) direct balancing of the energy consumption of the principal large consumers and of the individual sectors of consumption in accordance with the planned development;

(iiiii) parallel appraisals of development in other countries with similar structural relationships and in a similar stage of development.

Because the results obtained by the above mentioned methods may differ greatly, it is necessary to make a critical choice of the appropriate values for drawing up the balance of energy.

(c) An estimate of the Yugoslav fuel and power requirements according to these methods was made for the following sectors of consumption: industry, transport and mass consumption while the needs of agriculture are determined in accordance with the provisions of motorization and mechanization.

The following tabular summary gives the data obtained by the methods (i), (ii), (iii) and (iiii), assuming that during the next ten years the volume of the National Product of industry will increase at the same rate of growth as during the foregoing ten year period, that transport will grow at a rate slightly higher than during the foregoing period and that mass consumption will increase at the same rate of growth as during the past period. If the results obtained according to method four (iiii) are marked 100, the other methods show the following values:

	For the period of:							
	5 years				10 years			
	Total	Industry	Transport	Mass consumption	Total	Industry	Transport	Mass consumption
(i) Linear extrapolation	88	91	103	84	75	72	95	75
(ii) Exponential trend	105	111	103	106	109	114	100	128
(iii) Extrapolation of interdependence	117	118	110	112	124	111	105	120
(iiii) Balancing on the basis of the foreseen development of the main sectors of consumption	100	100	100	100	100	100	100	100

Experience shows that the linear trend regularly gives values too low irrespective of whether the calculations are made for a shorter or longer period of time. The interdependence method gives higher values, while the exponential trend which ensures a constant rate of growth, gives approximately realistic values, but only for a short period. The exponential trend method and the interdependence method do not include the effects of the improvement of the technological process of the production and consumption of energy. From this it follows that the values to be considered most reliable are those obtained by the method of balancing the main sectors of consumption, including at the same time the foreseen development of the various sectors and the effects of a more economical production and consumption of fuel and power.

5. Principles underlying the maintenance of fuel and power supply with reference to some specific details

(a) The supply of the estimated needs of fuel and power was based primarily on the utilization of domestic sources of fuel and power and that in such a way, that priority was accorded to the kinds of energy, the exploitation and utilization of which is most favourable in both production and consumption.

This scheme was realized through aiming at:

(i) maximum utilization of petroleum and natural gas reserves with the understanding that the key-derivatives (gas-oil and petrol) are produced in the inland refineries irrespective of the available quantities of domestic crude petroleum;

(ii) building of the most economical hydroelectric power plants in order to ensure a favourable relation between hydroelectric and thermoelectric power.

(iii) covering the electric power shortage with coal concentrating especially on mines where a large output at small production cost can be attained. When working large deposits of low grade coal the main goal is not the maximum utilization of the coal, but to exploit only the most profitable parts of the deposit.

(b) If this scheme is accepted, it is to be expected, that the various kinds of energy will share in the overall production as follows:

Year	Hydroelectric power	Coal	Petroleum and natural gas	Total
1951	17.4	79.7	2.9	100
1960	23.7	67	9.3	100
1965	23.7	58.6	17.7	100

(c) During the forecasting of the development of the power economy some special problems were taken into account which may have a considerable influence on the supply and the economic effects as a whole. The following are the most important:

(i) The balances of the possible generation of hydroelectric power are drawn up on the basis of the average dry year in order to ensure a greater regularity of supply. The necessary capacities of thermal electric power are determined in accordance with such a generation of hydroelectric power.

(ii) With regard to the predominantly low calorific value of coal (lignites) the solution aimed at was to locate the large coal consumers, first of all the thermoelectric plants, in the neighbourhood of the coal deposits. In spite of all such efforts, the share of coal in the total railway transportation of goods still amounts to 30 percent which has economically poor results. Therefore trouble has been taken to reduce such transportation to a minimum.

(iii) An important factor is also realistic planning of the time limits for the construction of fuel and power projects, so as to be able to satisfy the requirements on time. In connection with this it happened that in some cases the deadline of the contractors has had to be postponed. The reason being, that in some cases construction of new fuel and power projects (hydroelectric power stations, coal mines) had to begin before the survey and plans were completed and with insufficient mechanized equipment and experience. This was especially the case during the first period of construction.

(~~ii~~ iv) Another factor to take into account is the influence of the differences in temperature resulting from dissimilar climatic conditions in various years. In Yugoslavia although no special importance was attributed to this, it has presented no great difficulties.

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